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Pacific Ocean killer whale and other cetaceans Distribution survey, May 2007 (PODs 2007) conducted aboard the NOAA ship McArthur II

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Introduction

In 2001 the Southern resident killer whale (SRKW) population was petitioned for listing under the ESA. A series of workshops were held in 2003 and 2004 to identify data gaps and risk factors associated with the 20% decline this population experienced in the late 1990s. The primary data gap identified with this population was its winter distribution. Although the population has been identifiable since 1976, only 12 documented sightings in the winter in coastal waters existed in 2001, ranging form central California to the Queen Charlotte Islands, British Columbia. With the 2005 listing of the population under the ESA, Critical Habitat designation was required but in the initial designation none of the coastal U.S waters were included due to a paucity of sighting data. In order to obtain location data to improve the Critical Habitat designation, as well as obtain other information on behavior and prey selection, annual winter cruises to locate SRKWs have been conducted annually from 2004, except for the year 2005 (no sea days were allocated to this task in FY05). Here we report on the sighting and acoustic data collected for killer whales and other cetacean species and sea birds, as well as describe the oceanographic data collected during the Pacific Ocean killer whale and cetaceans Distribution survey, May 2007 (PODs 2007) conducted aboard the NOAA ship McArthur II.

Survey Objectives

The overall objective of this cruise was to locate southern resident killer whales (SRKWs) in order to better document their winter range as well as improve our understanding of their behavior and habitat use in these areas. In addition, other biological and oceanographic data were collected to better characterize their environment. Other objectives included photo-identification, behavioral observations, and acoustic study of sounds produced by other cetaceans in this area during the winter.

Study Area

The survey tracklines for the project included the waters of the continental shelf from southern Vancouver Island to central Oregon. This region is within the range of most of the documented sightings of SRKW during the early May timeframe.

Itinerary

The survey began on 3 May 2007 in Bellingham, Washington and ended on 15 May 2007 in Astoria, Oregon. A set of predetermined tracklines were established prior to the survey to cover the portion of the study area with the highest probability of encounter of SRKW based on previous sightings. In general, the ship was to initially follow the tracklines from the entrance of the Strait of Juan de Fuca north to Tofino, Vancouver Island. If no southern resident killer whales were encountered the ship followed a set of tracklines south, potentially as far as central Oregon, depending on weather and whale detections. The ship would then return north repeating these tracklines. Tracklines were modified during the cruise due to weather or other considerations. In addition, modifications were made by transiting directly to areas where recently reported sightings of killer whales were likely to be southern resident killer whales. The final ship track is shown in Figure 1.

Methods and Materials

Surveys were conducted for marine mammals and seabirds during this cruise. Two survey methods for marine mammals were used, visual and acoustic. In addition, oceanographic data were collected. Scientific Personnel that collected these data are listed in Table 1.

Visual Surveys

Marine Mammals

Line-transect survey methods were the primary visual survey method. This approach was consistent with Southwest Fisheries Science Center approach for use in estimating abundance (Kinzey et al. 2001). The *McArthur II* traveled at 9-10 knots (through the water) along the designated trackline. A daily watch for marine mammals was maintained during daylight hours by scientific observers on the fly-bridge (approximately 0700 to 1800), except when the ship was stopped to conduct other sampling operations, or when precluded by weather. A team of three observers searched with 25x150 binoculars, 7X binoculars, and unaided eye. The two outboard observers scanned from 10 degrees across the trackline to 90 degrees abeam with the Big eyes. The observers reported sighting angle using the azimuth incorporated into the binocular mount (this azimuth was calibrated to zero at the beginning of the cruise). The recorder monitored the entire 180 degree field of view with 7x 50 binoculars and unaided eye. Sighting conditions, watch effort, sightings, and other required information were entered into a computer, using the program WinCruz (written by R. Holland, SWFSC), hooked up to the ship's GPS (for course, speed and position information). Observers worked for 30 minutes at each of the three stations and rotated through the three positions for a total of 1.5 hours on the fly-bridge, with an hour break between sets of rotations.

If weather (Sea State greater than Beaufort 4, rain, or fog) precluded observations with the 25x binoculars, a two observer watch (designated off-effort) was manned on either the fly-bridge or bridge with 7x50 binoculars or unaided eye. The observers scanned with unaided eye and 7x50 binoculars for marine mammals. Sighting conditions, watch effort, sightings, and other required information were also entered into a computer, using the program WinCruz (written by R. Holland, SWFSC), hooked up to the ship's GPS (for course, speed and position information), but this was done by the observer.

On sighting a marine mammal or other feature of biological interest, the marine mammal observer team on watch occasionally requested the vessel be maneuvered to approach the cetacean school or feature for investigation. During these occasions, the team went off-effort to allow the ship to approach the group of marine mammals. During this time, the observers made estimates of group size. During certain sightings, behavioral data were collected and photographs were taken. Furthermore, in some instances, a small boat was deployed for biopsy, behavioral data collection, photographic and other operations. Depending on the duration and end location of the encounter the trackline was either resumed at the point of departure or intersected at the closet point, while ensuring that the line was not repeated.

Seabirds

Surveys of marine bird distribution were recorded by trained observers during all daylight hours when ship speed exceeded 2.5 m/s (5 knots). Three observers rotated through watches of two observers each, so that every observer had an opportunity to eat meals and rest as necessary to avoid fatigue. Observations began at dawn each morning. A primary observer counted and identified all flying or sitting birds within a strip transect extending 300 m out from the bow to the beam of the ship (90° arc). During mild weather, observations were collected from the flying bridge (deck height = 12.6 m) on the side of the vessel with the best viewing conditions for each survey. In the event of precipitation exceeding a light drizzle,

observations were collected from the bridge wing that was most in the lee of the wind (deck height 10.3m).

Binoculars (8x magnification) were used to aid in counting and species identification. Data were called out to a secondary observer who immediately entered them into a laptop computer running the "See-Bird" data acquisition program v 2.3.0 (Southwest Fisheries Science Center, La Jolla, CA). The computer was linked to GPS satellite data input so that each observation was associated with a time stamp and a latitude/longitude position. Standard behavior codes were noted and recorded (e.g., sitting, feeding, flight direction, etc). Marine mammals or large aggregations of seabirds observed beyond the observation zone were also recorded in the comments.

Acoustic survey - Two different types of acoustic monitoring systems were available during the cruise, a dual towed array system and sonobuoys.

Towed Arrays - hydrophones

The towed array system consisted of 2 hydrophones arrays: a 2 element array (array A); and a 5 element array (array B). Array A consisted of 2 elements with 3.15 m spacing and approximately 330m of lead in cable. The 2 elements for array A had an effective (i.e. flat) frequency response of 100 Hz – 40 kHz. Array A was the primary array deployed (i.e. day and night) during normal survey mode. Array B consisted of 5 elements consisting of two paired phones at either end with 3m spacing between each element in the pair, and a single hydrophone near the middle (330 m from the end pair and 130m from the first pair) for a total aperture of 660m (between the first and last pair). The last element of array B consisted of a broad-band, high-frequency element with a flat frequency response up to 200 kHz. Array B was intended to complement array A during nighttime encounters with resident killer whales in order to improve tracking capabilities. Each array was spooled on its own hydraulically powered winch for deployment and retrieval. Usually, array A was deployed at lengths of 200-300m from the fantail of the ship, depending on the bottom depth and other factors. Approximately 10 lbs of lead weight was attached to each array approximately 180m from the end of the array to sink it to a suitable depth. Array B was deployed with 200m of cable from the first pair of elements (for a total length of ~ 660m).

The deck cable was connected to the dry end of the array after deployment via a weather-proof electronic connector. The deck cable led from the winch into the dry-lab where the array power supply, signal conditioning, and signal processing, and signal recording system were located on the McArthur II. Array A was powered by two 12V DC batteries using a differential power (positive, negative & ground) configuration. Array B was powered by a 16V gel-cell.

Towed Arrays - Signal conditioning system

Six channels from both arrays (2 elements from array A, and the first 4 elements from array B) were passed to a 6-channel low pass filter (Alligator Filter Tech. model AAF) set at a fixed 48 kHz corner frequency. The seventh channel (from hydrophone 5 of array B) was sent to a low-pass filter with a corner frequency set at 96 kHz. The signal was then split between a National Instruments 6062E DAQ card for (for high-frequency recordings) and a programmable band-pass filter (Krohn-Hite model 3362) with a corner frequency set at 48 kHz. The high pass filter was adjusted as needed between 500 Hz and 4 kHz (default set at 500Hz) and used to reduce any low-frequency engine and flow noise. All seven channels (i.e. all hydrophones from both arrays) were fed into a MOTU Traveler PC digital interface. The MOTU interface was used to digitize all seven channels of array signals and then sent to ISHMAEL via a fire-wire cable.

Towed Arrays - Signal processing and recording system

One laptop was dedicated for running ISHMAEL sound localization and digital recording software (developed by D. Mellinger, OSU-PMEL, Newport, OR). A second laptop was dedicated to running Whaletrack II (developed by Glenn Gailey, TAMUG, TX). These two computers were connected via a network connection to an Ethernet router which was used to pass information from ISHMAEL to Whaletrack II (see Appendix II for setup procedures).

ISHMAEL was used to record acoustic data and process calls for localization. Generally, data were sampled and recorded at 96 kHz for both arrays. Two-channels were recorded when array A was deployed and 7 channels (2 from array A, and 5 from array B) when both arrays were deployed. In some instances other sample rates and channels were recorded as needed. Recordings were made continuously at 10 minute intervals with times with most start-times aligned on the hour and every ten minutes after the hour.

Animal vocalizations were manually selected in ISHMAEL for localization by windowing the signal with a pointing device (e.g. a trackball or touchpad). Depending on localization method selected n ISHMAEL either a left-right ambiguous bearing, an un-ambiguous bearing, or a relative location was estimated. All bearings and locations were estimated relative to the ships location. Instantaneous estimates of locations were possible using a newly developed "crossed-pair" localization method in ISHMAEL. The bearing or location estimate and additional information were automatically passed to Whaletrack II via the network connection.

Whaletrack II was used to plot bearings and/or location estimates passed from ISHMAEL. Whaletrack II also acquired and plotted ship position via a serial GPS connection. Ship track history, current heading and speed as well as an estimated position of the array were calculated and stored in an MSAccess database created by Whaletrack II. Information about effort, acoustic contacts and settings of acoustic equipment (e.g. gain and filter cutoffs) were also recorded in Whaletrack II.

Bearings plotted in Whaletrack II were used to estimate the animal's location using a "sequential-bearing fix" technique. This technique involved sequentially plotting several bearings to the target while steadily moving past it. The locations of animal(s) were estimated visually by the computer operator who subjectively assessed the point where the bearing lines intersect. Bearings and estimated locations of animal calls were saved in a Whaletrack II database file. Screen dumps of bearing and ship plots were occasionally saved.

Sonobuoy System

Type AN/SSQ-57B USN sonobuoys (effective audio frequency response 10 Hz – 20 kHz) transmitting at various radio frequencies (164-167 MHz range) were deployed as conditions warranted. Sonobuoys are self-contained units that automatically power-up upon contact with water and transmit sounds via radio waves. All sonobuoys were set at 90m hydrophone deployment depths and 8 hour operating life (auto-scuttle setting). The sonobuoy radio signals were received by a mast mounted antennae connected to an ICOM IC-PCR1000 receiver that was controlled through a PC-based software interface. Acoustic signals from the receiver were recorded to a hard-drive using ISHMAEL and a NI 6062E DAQ card or the internal PC sound card.

Towed Arrays - Monitoring

Array A was monitored 24/7 weather permitting and except for oceanographic data collection (CTD deployment) as the ship proceeded on the tracklines. The vessel slowed from survey speed to approximately 3 knots at the midpoint of each line in order to provide improved acoustic monitoring conditions. Array B was deployed primarily at night, to facilitate tracking, and recovered in the morning. On occasion it was left out during the daytime. The array(s) were retrieved during nighttime CTD operations (usually between 20:00 and 21:00) but were re-deployed immediately afterwards. Only 2 channel recordings were made from Array A, even when both arrays were deployed. This allowed faster computational times when obtaining bearings and localizations.

A single visual observer on the flying bridge monitored the 2 element array aurally using a headset at all times when the visual team was on effort. If a killer whale vocalization was detected (or possibly detected), a member of bio-acoustics team was called to begin acoustics monitoring in the acoustics lab and proceed to attempt to localize calls. If killer whale sounds were detected at night, the bio-acoustician on watch would attempt to localize and track them until the visual observers came on watch at daybreak.

If southern resident killer whales were detected, every effort was made to remain with these animals for as long as possible. Visual sightings as well as acoustic data from the towed acoustic array or sonobouys were used to track the whales. Behavioral data were collected during visual observations, and if weather permitted, a small boat was deployed in order collect behavioral data, predation event remains, and photographs.

Photo-ID Photographs of marine mammals were taken on an opportunistic basis. The animals were either approached by the research vessel during normal survey operations, approached the research vessel on their own, or were approached by a small boat. Photographs of individuals were taken with digital 35 mm SLR cameras using 300 and 400 mm lenses for those species that have photo-ID existing catalogs.

Biopsy Sampling - Biopsies for genetic analyses of killer whales were collected on an opportunistic basis in U.S. waters. Samples collected for killer whales were only taken from small boats using the method outlined by Barrett-Leonard et al. (1996). Biopsy samples taken from the research vessel were collected from animals within 10m to 30m of the bow of the vessel using a dart fired from a dart rifle (S. Claussen per.comm.).

Prey remains collection – Prey remains from predation events of marine mammals were collected on an opportunistic basis. These samples were collected from animals that were approached by the small boat.

Behavioral Observations – Behavioral observations of marine mammals were taken on an opportunistic basis. The animals to be observed were approached by the research vessel during normal survey operations, approached the vessel on their own, or were approached by a small boat.

Oceanography

Thermosalinograph Sampling

The ship's Sea-bird Electronics Thermosalinograph (TSG) sampled surface water temperature and salinity continuously during the entire cruise track. The data from the TSG and from a GPS were continuously recorded by the ship's Scientific Computing System (SCS). The TSG information was also used in the field by the oceanographer to record latitude, longitude, surface water temperature, and salinity during expendable bathyothermograph (XBT) casts, surface water sampling, and CTD casts.

Expendable Bathyothermographs (XBTs) Deployment

Expendable bathyothermographs (XBTs) were deployed at 0900, 1200, and 1500 hours, and surface water samples were collected at 0600, 0900, 1200, 1500, and 1800 hours local ship time, and at other times, under the discretion of the Chief Scientist (e.g., surface water samples are also taken every hour when in the presence of Southern Resident killer whales). For XBT deployments, Sippican Deep Blue probes were used and data were transmitted to the Shipboard Environmental data Acquisition System. After each XBT drop, a surface water sample for chlorophyll a analysis was collected in a bucket deployed over the side of the ship. Immediately following bucket sampling, a 50 ml sample of the water was filtered onto a 2.5 cm GF/F filter. All filters were wrapped in foil, labeled, and stored frozen in Ziploc freezer bags until sample analysis, which occurred on the ship within <1-2 weeks of collection. For extraction, the filters were placed in culture tubes with 8 ml of 90% (v/v) acetone and stored in the freezer for a minimum of 2 hours. The tubes were then allowed to equilibrate with room temperature, and fluorescence was measured using a Turner Designs 10-AU Digital Field Fluorometer.

CTD Casts

A CTD (conductivity-temperature-depth) station was occupied each evening one hour after sunset, weather and sufficient depth permitting. In the event that a CTD cast was cancelled due to inclement weather or because the ship was tracking killer whales, an XBT was also deployed when the surface water sample was collected at 1800 hours. CTD data and seawater samples were collected using a SeaBird 9/11+ CTD with a 12-place rosette and Niskin bottles. All casts were to 1000m (depth permitting) with the descent rate set at 30 m/min for the first 100m of the cast, then 60 m/min after that, including the upcast between bottles. Niskin bottle water samples were collected at 12 standard depths (0, 10, 20, 30, 40, 50, 75, 100, 150, 200, 500, 1000) between the surface and 1000 meters, or to within 10 m of the bottom. For each cast, water samples were collected for chlorophyll a analysis at all depths to 200 m. Immediately following sampling, a 50 ml sample of the water was filtered onto a 2.5 cm GF/F filter. All filters were wrapped in foil, labeled, and stored frozen in Ziploc freezer bags until sample analysis, which occurred on the ship within <1-2 weeks of collection. Chlorophyll a extraction and analysis were conducted using the same protocol as above. Water samples for salinity analysis were collected at 100, 500, and 1000 m (or to within 10 m of bottom). Three additional salt samples were collected every other day so that the depths sampled were 30 m, 100m, 150m, 200 m, 500 m, and 1000 m. Water samples for salinity analysis were stored upright at ambient room temperature. Salinity samples were processed within one month after the cruise at the University of Washington Marine Chemistry Laboratory in Seattle. Water samples (approximately 40 ml) for nutrient analysis from each of the 11 depths up to 500 m were transferred into pre-rinsed (10% HCl and H2O) vials and frozen upright. Nutrient samples were processed within 1 year after the cruise, at the University of Washington Marine Chemistry Laboratory in Seattle.

Results and Discussion

Search Effort and Sightings – Marine mammals

A total of 2296.2 km were surveyed in the 11 available sea days, yielding an average of 208.7 km/day (Table 2, Figure 2). However, only 1110.8 km were considered on-effort, and of the 1185.4 km total off–effort, 321.3.8 km were conducted on the fly-bridge and 864.1 were conducted on the bridge. Visual effort was hampered from 6-8 May due to heavy fog.

A total of 91 sightings were made during all effort categories (Table 3). The majority of sightings were made while on-effort (56) although a substantial numbers were observed while off–effort (35) (Table 4). Six identifiable cetacean species were sighted (Figures 3). The most commonly sighted species were

humpback whales, followed by unidentified large whales, and Dall's porpoise. Only one group of killer whales (transients) was initially sighted without an acoustic cue (see Acoustics section). No ship-based biopsy attempts were made. We collected three biopsy samples from the transient killer whales encountered on 13 May in U.S. waters.

Search effort and sightings - Seabirds

A total of 1800.5 kilometers of on-effort survey observations were collected between 03 May 2007 and 14 May 2007; total effort in linear distance for each day is shown in Table 5. The three numerically dominant seabird species observed were sooty shearwaters (*Puffinus griseus*, 58.6%), common murres (*Uria aalge*, 20.5%), and red-necked phalaropes (*Phalaropus lobatus*, 7.6%; Table 6). The first two species are common as summer residents off the coast of Oregon and Washington; phalaropes are spring migrants moving through coastal waters en route to breeding grounds in the Arctic. The presence of both summer residents and spring migrants indicates the survey likely took place during the latter half of spring seabird, shorebird, and waterfowl migrations.

Acoustic detections

Of the 13 days at sea, the towed array system (i.e. at least one towed array) was deployed and monitored for a total of 256 hours. Excluding the first and last days (when partial days only were possible) average daily acoustic effort (day and night) was approximately 22.3 hours per day. This represents 93% of the total survey time at sea. If approximately one hour per day for the CTD cast is excluded, the acoustic effort approaches 97% of the available time (23 hrs/day) at sea. All acoustic data during on-effort period were digitally recorded to hard drives. There were no significant malfunctions of the acoustic array or any related acoustic hardware.

Four acoustic detections were made during the cruise. Three of the four detections were of killer whales, the other being an unidentified cetacean. One of these detections allowed localization to get a visual sighting (Table 7, Figure 4).

Killer whale encounters

Two of the three ecotype of killer whales found in the North Pacific Ocean, transients and residents, were encountered during the cruise (Table 8). For the resident type, a pod from only the northern community was observed. Northern residents were encountered on one occasion over the survey period and this was in Canadian waters. We also encountered a group of transients near the west entrance of the Strait of Juan de Fuca. This group was foraging on a Steller seal lion We were able to conduct small boat operations with this group of whales for about two hours and three biopsy samples were collected.

Oceanography

Thirty-seven XBT deployments and ten CTD deployments were made during the cruise (Table 9, 10, 11, Figure 5). Sixty-seven surface chlorophyll samples, Ninety-three CTD chlorophyll samples, thirty salinity samples, and one hundred nutrient samples were collected.

Acknowledgements

We are grateful to the Officers and crew of the McArthur II for their support, and their expertise was essential to the success of this cruise. The accomplishments of the cruise would not have been possible without the dedication and hard work of the research team participants. Cruise logistics were assisted by NWFSC staff, including Christel Martin, and Nick Adams and other staff from Vera Trainer's program. We appreciate the support and assistance of several colleagues at the SWFSC. Special thanks to Damon Holzer, NWFSC for expert development of the figures. Marine mammal research in the U.S. was conducted under NMFS Permit No. 782-1824-01 issued to the NWFSC and in Canada under DFO Marine Mammal License 2007-03 and SARA License 64.

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Table 1. Participating scientists from 3-15 May 2007 during PODs 2007.

Name[1]	**Position**	**Org**
Brad Hanson	Chief Scientist, Mammal Observer	NWFSC
Dawn Noren	Co-Cruise Leader, Mammal Observer	NWFSC
Candi Emmons	Killer whale ID Specialist	NWFSC
Stephen Claussen	Mammal Observer	Biowaves
Eric Ward	Mammal Observer	NWFSC
Marla Holt	Acoustician	NWFSC
Aly Azarra	Acoustician	Biowaves
Deborah Giles	Acoustician	NWFSC
Shelly Nance	Oceanographer	NWFSC
Troy Guy	Seabird Observer	OSU/NWFSC
Scott Mills	Seabird Observer	NWFSC
Brendan Courtot	Seabird Observer	NWFSC

Table 2. Visual survey effort summary for cetaceans (kms) by sea state from 3-15 May 2007 during PODs 2007.

Effort type	Sea State							
	0	1	2	3	4	5	6	Total
On Effort Flying Bridge	0	36.9	71.4	364.5	293.8	262.6	81.6	1110.8
Off Effort Flying bridge	0	3.2	19.9	58.7	99.5	37.2	102.8	321.3
Off Effort Bridge	58.3	101.4	145.3	80.8	73.0	122.3	283.0	864.1
Total	58.3	141.5	236.5	504.0	466.3	422.1	467.4	2296.2

Table 3. Visual sightings summary - Cetaceans - 3-15 May 2007 during PODs 2007.

Code	Species	Total Sightings	Average group size
37	*Orcinus orca*	2	*
40	*Phocoena phocoena*	1	1
44	*Phocoenoides dalli*	13	4.3
71	*Balaenoptera acutorostrata*	1	1
74	*Balaenoptera physalus*	2	2.5
76	*Megaptera novaeangliae*	33	2.2
78	Unid. small whale	2	1
79	Unid. large whale	32	1.7
98	Unid. whale	4	1.7
477	Unid. porpoise	1	1
	Total	91	

* see Table 4

Table 4. Cetacean sightings from 3-15 May 2007 during PODs 2007.

Sighting #	Date	Time	Lat	Long	Species code	Species	# of animals	Effort
1	4-May	8:55	N48:38.38	W125:19.18	44	Pd	2	On
2	4-May	9:54	N48:41.32	W125:12.90	44	Pd	1	On
3	4-May	11:25	N48:33.26	W125:30.66	44	Pd	1	On
4	4-May	12:17	N48:28.70	W125:40.71	477	Unid porpoise	1	On
5	4-May	13:14	N48:23.90	W125:50.87	79	Unid Lg Whale	1	On
6	4-May	13:36	N48:21.81	W125:54.51	76	Mn	2	On
7	4-May	14:08	N48:20.67	W125:59.86	98	Unid Whale	2	On
8	4-May	15:47	N48:32.31	W125:45.11	76	Mn	2	On
9	4-May	16:07	N48:34.29	W125:42.87	79	Unid Lg Whale	1	On
10	4-May	16:25	N48:36.70	W125:39.77	98	Unid Whale	1	On
11	4-May	17:13	N48:42.27	W125:32.82	76	Mn	2	On
12	4-May	17:47	N48:46.39	W125:27.82	79	Unid Lg Whale	1	On
13	4-May	18:13	N48:48.02	W125:26.00	76	Mn	2	On
14	4-May	18:20	N48:47.71	W125:27.52	76	Mn	2	On
15	4-May	18:25	N48:47.49	W125:28.55	76	Mn	2	On
16	4-May	18:33	N48:47.08	W125:30.15	76	Mn	2	On
17	4-May	18:44	N48:46.44	W125:32.55	76	Mn	3	On
18	4-May	19:03	N48:45.41	W125:36.44	98	Unid Whale	2	On
19	5-May	6:57	N48:42.86	W126:08.86	79	Unid Lg Whale	3	On
20	5-May	7:28	N48:47.73	W126:06.44	76	Mn	2	On
21	5-May	7:50	N48:51.35	W126:06.88	76	Mn	3	On
22	5-May	8:00	N48:53.52	W126:07.33	76	Mn	2	On
23	5-May	8:11	N48:55.24	W126:07.85	37	Oo - G's	*	
24	5-May	9:02	N48:56.04	W126:12.06	76	Mn	5	Off
25	5-May	9:03	N48:56.12	W126:12.11	76	Mn	5	Off
26	5-May	9:07	N48:56.23	W126:12.30	74	Bp	4	Off
27	5-May	11:43	N49:01.99	W126:03.33	76	Mn	3	Off
28	5-May	12:12	N49:01.10	W126:09.79	76	Mn	3	Off
29	5-May	12:27	N49:00.21	W126:13.16	76	Mn	1	Off
30	5-May	12:57	N48:58.51	W126:19.68	71	Ba	1	Off
31	5-May	15:00	N48:55.62	W126:27.40	76	Mn	1	Off
32	5-May	16:20	N48:57.68	W126:12.72	79	Unid Lg Whale	1	Off
33	5-May	16:28	N48:56.66	W126:12.13	79	Unid Lg Whale	1	Off
34	5-May	16:48	N48:54.64	W126:11.06	79	Unid Lg Whale	1	Off
35	5-May	16:54	N48:53.29	W126:10.29	76	Mn	3	Off
36	5-May	17:07	N48:51.76	W126:09.29	76	Mn	2	Off
37	5-May	18:44	N48:38.41	W126:01.75	76	Mn	2	Off
38	6-May	11:17	N48:03.00	W125:08.57	76	Mn	2	Off
39	6-May	14:16	N47:57.28	W125:12.24	76	Mn	2	Off
40	7-May	7:52	N47:04.17	W124:32.60	40	Pp	1	Off
41	7-May	10:37	N46:54.85	W124:47.99	44	Pd	10	Off
42	7-May	18:38	N46:39.51	W124:37.32	44	Pd	5	Off
43	8-May	13:07	N46:06.65	W124:27.13	76	Mn	2	On
44	8-May	14:54	N46:02.56	W124:45.64	76	Mn	1	On
45	8-May	17:35	N45:57.83	W124:13.49	79	Unid Lg Whale	1	On

* Complete estimates of group size were not be made

Table 4. Cetacean sightings during PODs 2007, cont

Sighting #	Date	Time	Lat	Long	Species code	Species	# of animals	Effort
46	8-May	19:33	N45:51.11	W124:26.06	44	Pd	2	Off
47	9-May	7:24	N45:14.13	W124:09.47	79	Unid Lg Whale	1	On
48	9-May	12:36	N44:48.41	W124:26.07	79	Unid Lg Whale	4	Off
49	9-May	12:54	N44:47.44	W124:29.55	74	Bp	1	Off
50	9-May	12:58	N44:47.04	W124:31.01	79	Unid Lg Whale	1	Off
51	9-May	13:03	N44:46.74	W124:32.10	79	Unid Lg Whale	1	On
52	9-May	13:05	N44:46.66	W124:32.38	79	Unid Lg Whale	2	Off
53	9-May	13:14	N44:46.16	W124:34.39	79	Unid Lg Whale	2	On
54	9-May	14:05	N44:43.33	W124:45.21	76	Mn	1	Off
55	9-May	19:50	N44:23.04	W124:29.26	79	Unid Lg Whale	1	Off
56	10-May	15:07	N44:51.16	W124:16.30	79	Unid Lg Whale	8	Off
57	10-May	16:19	N44:56.32	W124:10.29	79	Unid Lg Whale	2	Off
58	10-May	16:24	N44:56.90	W124:10.93	79	Unid Lg Whale	2	On
59	10-May	16:41	N44:57.99	W124:12.12	79	Unid Lg Whale	2	On
60	10-May	16:43	N44:58.21	W124:12.36	79	Unid Lg Whale	1	On
61	10-May	16:44	N44:58.29	W124:12.45	79	Unid Lg Whale	4	On
62	10-May	16:47	N44:59.31	W124:13.55	79	Unid Lg Whale	1	On
63	10-May	17:05	N45:00.53	W124:13.24	76	Mn	2	On
64	10-May	17:05	N45:00.72	W124:13.24	79	Unid Lg Whale	1	On
65	10-May	17:09	N45:00.73	W124:13.22	79	Unid Lg Whale	1	On
66	11-May	8:03	N46:05.51	W124:33.63	44	Pd	7	On
67	11-May	8:58	N46:07.27	W124:22.93	44	Pd	6	On
68	11-May	11:54	N46:11.91	W124:33.68	79	Unid Lg Whale	1	On
69	11-May	13:02	N46:13.87	W124:37.11	79	Unid Lg Whale	1	Off
70	12-May	8:33	N46:51.00	W124:49.20	79	Unid Lg Whale	2	Off
71	12-May	10:02	N46:54.24	W124:27.78	79	Unid Lg Whale	1	Off
72	12-May	11:25	N46:54.66	W124:44.76	44	Pd	4	Off
73	12-May	12:18	N46:55.68	W124:51.42	76	Mn	3	On
74	12-May	16:13	N47:05.34	W124:52.38	76	Mn	2	On
75	12-May	16:54	N47:06.72	W124:57.06	76	Mn	2	Off
76	12-May	18:06	N47:12.78	W124:43.80	76	Mn	2	On
77	13-May	7:12	N48:03.13	W125:05.39	76	Mn	2	Off
78	13-May	9:04	N48:00.26	W125:30.52	76	Mn	1	On
79	13-May	10:54	N47:59.98	W125:34.00	79	Unid Lg Whale	3	Off
80	13-May	11:18	N48:00.22	W125:36.82	79	Unid Lg Whale	1	On
81	13-May	12:00	N48:01.20	W125:38.83	98	Unid Whale	2	On
82	13-May	13:27	N48:10.62	W125:22.05	79	Unid Lg Whale	1	On
83	13-May	14:12	N48:15.40	W125:13.21	44	Pd	3	On
84	13-May	15:00	N48:20.43	W125:04.24	44	Pd	12	On
85	13-May	15:22	N48:22.13	W125:01.29	44	Pd	2	On
86	13-May	15:47	N48:24.94	W124:56.14	37	Oo T's	*	On
87	14-May	7:07	N47:21.61	W124:33.35	78	Unid Sm Whale	1	On
88	14-May	7:47	N47:14.68	W124:30.71	78	Unid Sm Whale	1	On
89	14-May	10:03	N46:58.38	W124:43.34	76	Mn	2	On
90	14-May	13:20	N46:46.63	W124:23.05	79	Unid Lg Whale	1	On
91	14-May	15:00	N46:44.85	W124:32.72	44	Pd	1	On

* Complete estimates of group size were not be made

Table 5. Marine bird survey effort, in linear distance surveyed day, 3 - 15 May 2007.during PODs 2007.

Date	On-effort survey distance (km)
3-May-2007	63.3
4-May-2007	202.4
5-May-2007	73.6
6-May-2007	153.0
7-May-2007	9.4
8-May-2007	156.2
9-May-2007	226.1
10-May-2007	173.6
11-May-2007	196.1
12-May-2007	195.6
13-May-2007	129.9
14-May-2007	221.3
Total	1800.5

Table 6. Total counts of species recorded during marine bird survey effort, in descending numerical order, 3-15 May 2007, during PODs 2007.

Common Name	Scientific name	Total count	Percentage of total
Sooty Shearwater	*Puffinus griseus*	11805	58.8
Common Murre	*Uria aalge*	4135	20.5
Red-necked phalarope	*Phalaropus lobatus*	1543	7.6
Western x Glaucous-winged Gull	*Larus spp.*	908	4.5
Rhinoceros Auklet	*Cerorhinca monocerata*	427	2.1
Black-footed albatross	*Phoebastria nigripes*	219	1.1
Surf Scoter	*Melanitta perspicillata*	194	1.0
Fork-tailed Storm-petrel	*Oceanodroma furcata*	152	0.8
Sabine's gull	*Xema sabini*	150	0.7
Pacific Loon	*Gavia pacifica*	114	0.6
Northern Fulmar	*Fulmarus glacialis*	74	0.4
Cassin's Auklet	*Ptychoramphus aleuticus*	60	0.3
Pink-footed shearwater	*Puffinus creatopus*	57	0.3
Tufted puffin	*Fratercula cirrhata*	55	0.3
Brant	*Branta bernicla*	52	0.3
Unidentified shorebird	Suborder Charadrii	29	0.1
Brandt's cormorant	*Phalacrocorax penicillatus*	24	0.1
Glaucous-winged gull	*Larus glaucescens*	24	0.1
Herring gull	*Larus argentatus*	19	0.1
Arctic tern	*Sterna paradisaea*	14	0.1
Parakeet auklet	*Cyclorrhynchus psittacula*	14	0.1
Black-legged Kittiwake	*Rissa tridactyla*	13	0.1
Marbled murrelet	*Brachyramphus marmoratus*	10	0.0
Unidentified Alcid	*Family Alcidae*	9	0.0
Common Loon	*Gavia immer*	8	0.0
Unidentified duck	*Anas spp.*	8	0.0
Red phalarope	*Phalaropus fulicarius*	8	0.0

Table 6 cont. Total counts of species recorded during marine bird survey effort, in descending numerical order, 3-15 May 2007, during PODs 2007.

Common Name	Scientific name	Total count	Percentage of total
Mew Gull	*Larus canus*	7	0.0
Passerine	Order Passeriformes	7	0.0
Bonaparte's Gull	*Larus philadelphia*	6	0.0
Ancient Murrelet	*Synthliboramphus antiquus*	6	0.0
Pomarine Jaeger	*Stercorarius pomarinus*	5	0.0
Unidentified Gull	*Larus spp.*	5	0.0
California Gull	*Larus californicus*	5	0.0
Pelagic Cormorant	*Phalacrocorax pelagicus*	4	0.0
White-winged scoter	*Melanitta fusca*	3	0.0
Pigeon guillemot	*Cepphus columba*	3	0.0
Unidentified tern	*Sterna spp,*	2	0.0
Unidentified loon	*Gavia spp.*	1	0.0
Red-necked grebe	*Podiceps grisegena*	1	0.0
Laysan albatross	*Diomedea immutabilis*	1	0.0
Manx shearwater	*Puffinus puffinus*	1	0.0
Brown pelican	*Pelecanus occidentalis*	1	0.0
Double-crested Cormorant	*Phalacrocorax auritus*	1	0.0
Parasitic Jaeger	*Stercorarius parasiticus*	1	0.0
Western Gull	*Larus occidentalis*	1	0.0
Thayer's Gull	*Larus thayeri*	1	0.0
Horned Puffin	*Fratercula corniculata*	1	0.0
TOTALS		**20188**	**100.0%**

Table 7. Acoustic detections of marine mammals from 3 - 15 May 2007.during PODs 2007.

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Date	Time	Latitude	Longitude	Species	Ecotype
5/5/2007	1:45	48.699	-126.09	O. orca	N. residents
5/13/2007	9:35	47.990	-125.625	O. orca	Unidentified
5/13/2007	16:36	48.402	-124.866	O. orca	Transient
5/15/2007	4:35	46.216	-124.765	Unid Cetacean	

Table 8. Killer whale encounters from 3 - 15 May 2007.during PODs 2007.

Date	Duration of encounter	Latitude	Longitude	Ecotype	Whales Present
5/5/2007	7:52	48.699	-126.09	Resident	G2, G77, G49, G71, G34, G70, G27, G64, G76?, G58?, G41, G53, G62, G45
5/13/2007	0:06	47.990	-125.625	Transients	Unk.
5/13/2007	0:50	48.402	-124.866	Transients	T185, T185's new calf, T186, T187, T46, T46C,T46D, T46E, T46B, T46B1, T122 and maybe T47

Table 9. Summary of environmental data from 3-15 May 2007 during PODs 2007.

Sample type	Cruise total
CTD casts	10
CTD chlorophyll samples	93
Surface chlorophyll samples	67
Nutrient samples	100
Salinity samples	30
XBT drops	37

Table 10. XBT deployment locations from 3 - 15 May 2007 during PODs 2007.

XBT #	Serial #	Max depth (m)	Sea surface temp (°C)	PST Date	PST time	Latitude	Longitude
1	973326	183	9.9	4-May	1756	N48:15.08	W123:32.29
2	973330	120	10.5	4-May	900	N48:35.71	W125:18.77
3	973323	100	10.7	4-May	1200	N48:29.84	W125:38.17
4	973327	145	10.9	4-May	1500	N48:25.63	W125:47.35
5	973331	133	10.9	4-May	1505	N48:25.63	W125:47.35
6	973324	104	10.6	5-May	1043	N48:56.37	W126:10.73
7	973332	69	10.4	5-May	1200	N49:01.78	W126:07.18
8	973328	165	10.1	5-May	1500	N48:55.47	W126:28.20
9	1006761	220	9.9	6-May	900	N47:59.12	W125;40.18
10	1006754	108	10.5	6-May	1201	N48:04.25	W124:58.62
11	1006757	615	10.5	6-May	1500	N47:53.25	W125:20.09
12	1006753	100	11.2	7-May	900	N47:00.20	W124:38.09
13	1006762	128	11.4	7-May	1200	N48:50.17	W124:39.17
14	1006763	144	12.0	7-May	1500	N46:46.47	W124:42.12
15	1006759	120	11.4	8-May	900	N46:13.39	W124:39.99
16	1006755	75	11.5	8-May	1200	N46:09.05	W124:10.75
17	1006760	310	11.4	8-May	1450	N46:02.81	W124:47.00
18	1006764	365	11.3	9-May	900	N45:06.34	W124:29.14
19	1006756	360	11.4	9-May	910	N46:05.25	W124:29.31
20	1006717	135	10.2	9-May	1200	N44:50.76	W124:18.26
21	1006721	400	11.8	9-May	1500	N44:39.75	W124:48.90
22	1006725	105	9.7	10-May	900	N44:14.41	W124:36.68
23	1006722	80	9.5	10-May	1200	N44:32.71	W124:20.98
24	1006726	131	9.6	10-May	1500	N44:50.89	W124:17.31
25	1006718	120	10.6	11-May	900	N46:07.32	W124:22.50
26	1006723	265	11.3	11-May	1200	N46:12.00	W124:35.12
27	1006727	67	10.4	11-May	1500	N46:17.58	W124:15.44
28	1006719	85	11.2	11-May	2000	N46:26.45	W124:21.35
29	1006728	86	10.5	12-May	900	N46:52.29	W124:28.96
30	1006724	316	10.6	12-May	1200	N46:54.96	W124:52.32
31	1006720	86	9.5	12-May	1500	N47:04.33	W124:36.70
32	973132	165	10.3	13-May	900	N48:00.23	W125:30.79
33	973131	316	10.4	13-May	1200	N48:00.97	W125:39.20
34	973136	169	10.2	13-May	1500	N48:20.22	W125:04.55
35	973140	71	9.4	14-May	900	N47:03.30	W124:30.12
36	973135	106	9.5	14-May	1200	N46:54.40	W124:35.92
37	973139	109	10.2	14-May	1100	N46:44.88	W 124:32.64

Table 11. CTD deployment locations for CTDs from 3 - 15 May 2007 during PODs 2007.

CTD #	Number of depth sampled	Max depth (m)	PST Date	PST start time	Latitude	Longitude
1	9	150	4-May	2009	N48:25.63	W125:47.35
2	11	320	5-May	2151	N48:14.85	W125:51.00
3	8	100	6-May	2148	N47:35.92	W124:54.31
4	8	100	7-May	2205	N46:31.45	W124:26.97
5	12	500	8-May	2130	N45:48.15	W124:46.11
6	9	130	9-May	2132	N44:22.19	W124:45.63
7	9	130	10-May	2136	N45:24.86	W124:13.08
8	12	1000	12-May	2142	N47:24.81	W124:54.57
9	11	450	13-May	2154	N48:11.94	W125:40.47
10	12	725	14-May	2049	N46:44.87	W124:41.10

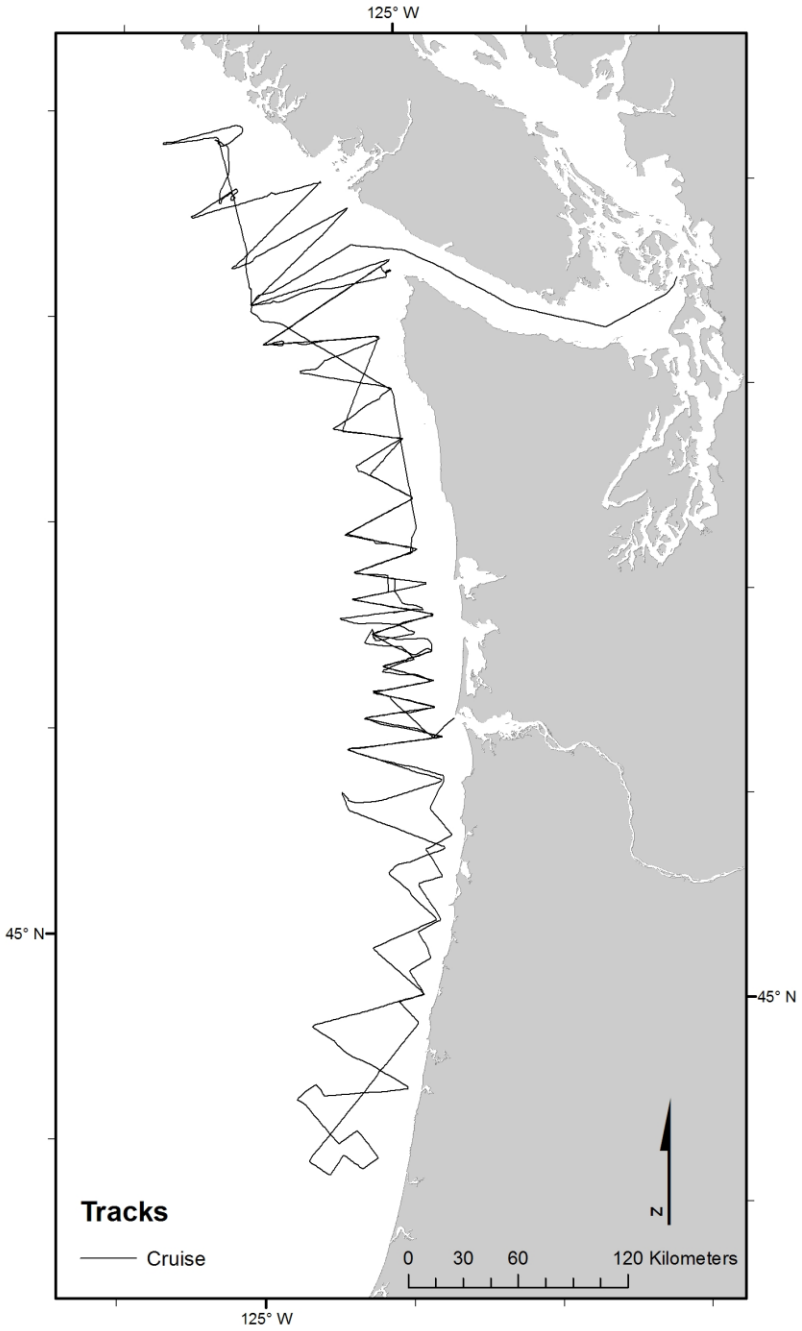

Figure 1. Cruise track of the McArthur II from 3 - 15 May 2007 during PODs 2007.

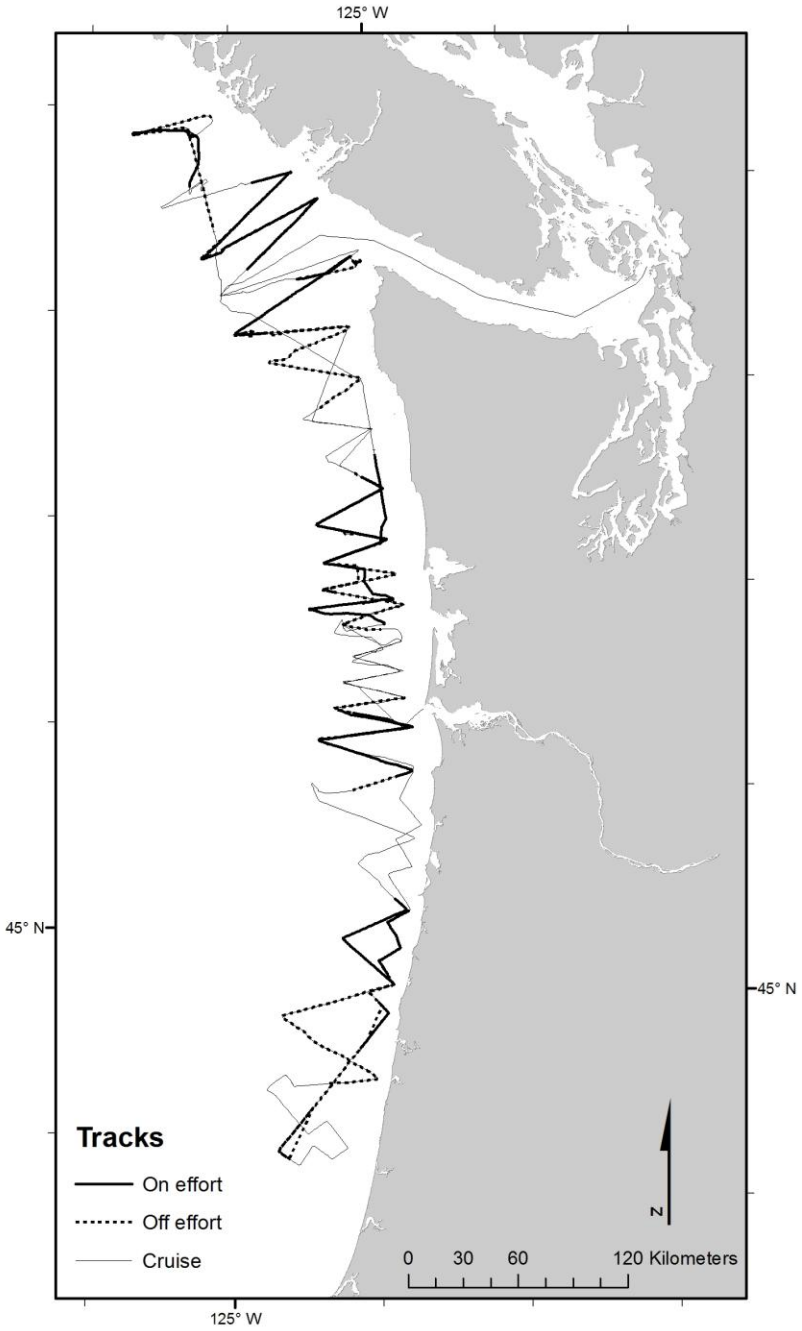

Figure 2. Visual On and Off –effort monitoring of marine mammals from 3 - 15 May 2007 during PODs 2007.

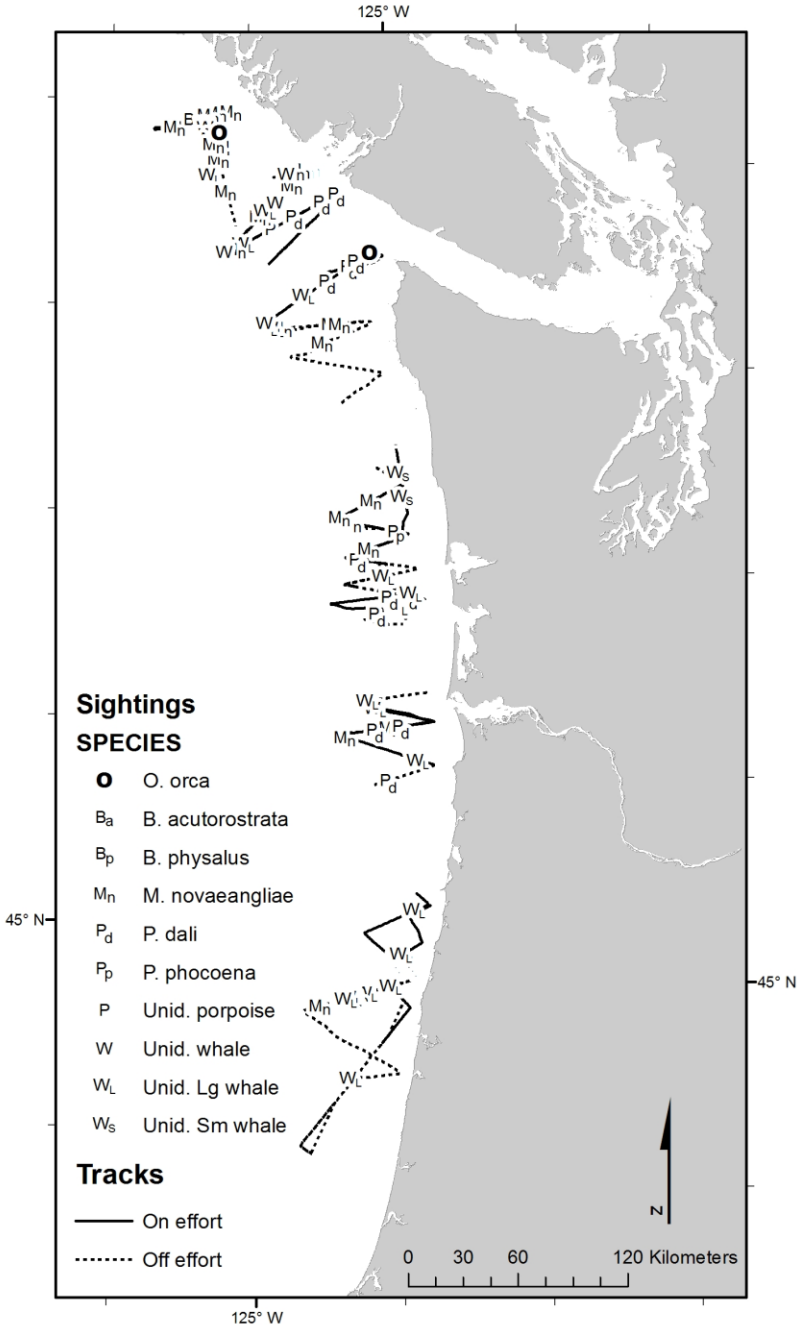

Figure 3. On and Off-effort sightings of cetaceans from 3 - 15 May 2007 during PODs 2007.

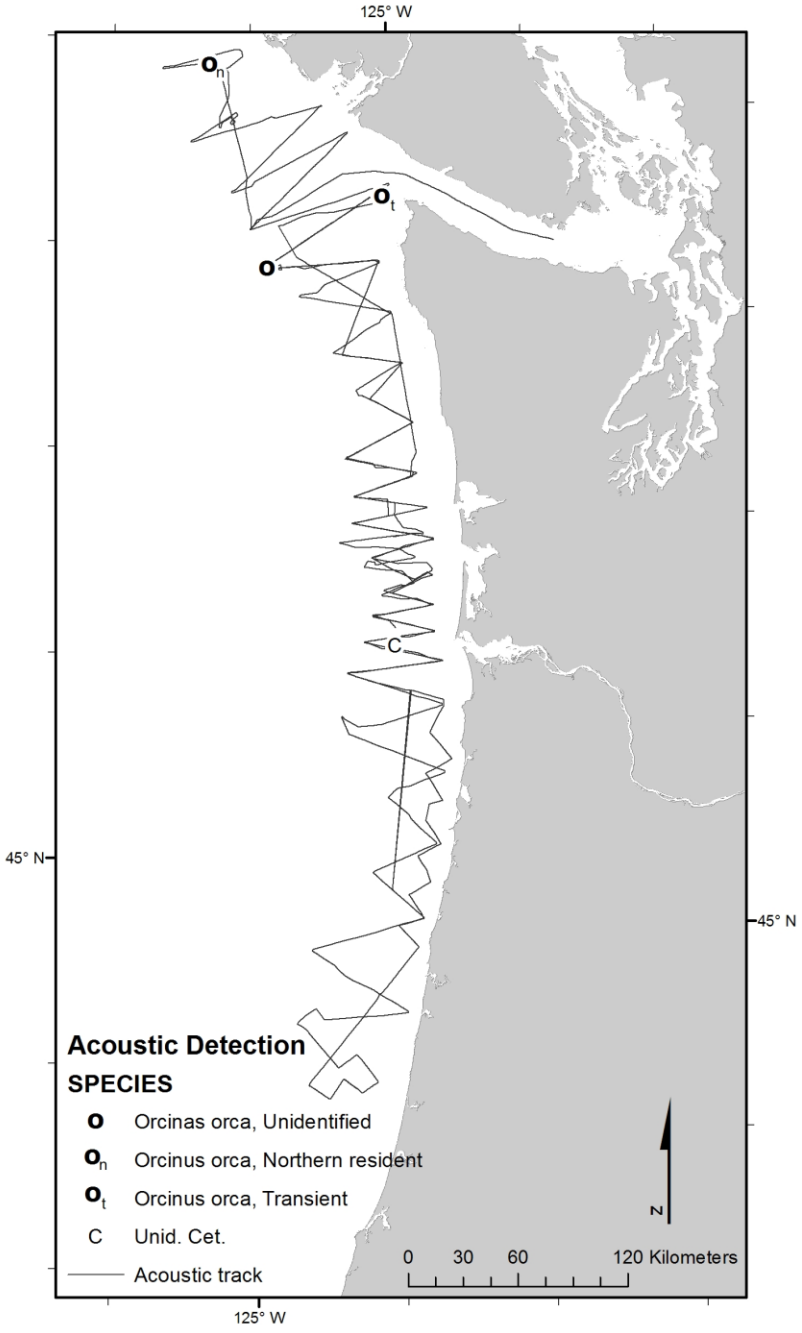

Figure 4. Acoustic detections of marine mammals from 3 - 15 May 2007 during PODs 2007.

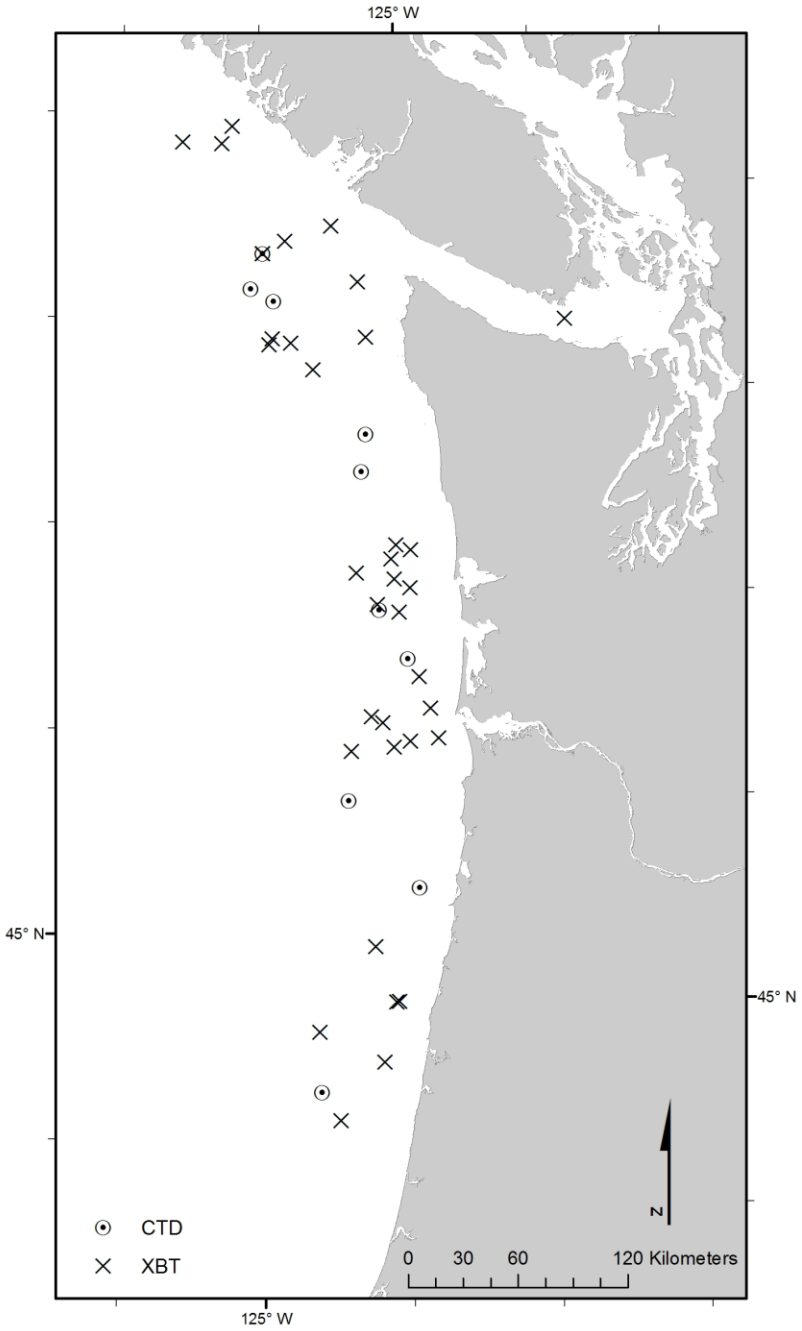

Figure 5. XBT and CTD deployments from 3 - 15 May 2007 during PODs 2007.